IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF: :

TOMIO MIMURA, ET AL : GROUP: 1764

SERIAL NO: 10/757,479 :

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FOR: GAS-LIQUID CONTACT PLATE AND AS-LIQUID CONTACTOR

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SIR

1. Now comes Naoyuki Yoshizumi, residing at Chiyoda-ku, Tokyo, Japan.

2. I am one of the co-inventors of the above-identified application.

3. I graduated from the Graduate School of Mechanical Engineering at Tokyo University of Science on March 1, 1999.

4. I have been employed by Mitsubishi Heavy Industries, Ltd. since April, 1999 and have been engaged in research and development at the Plant and Transportation Systems Engineering and Construction Center. I am now working in the Environmental Plant Engineering Group of the Environmental Project Department.

5. The following experiments were carried out under my supervision.

EXPERIMENTS

These experiments emphasize the significance of the functional effects of the limitation that a rate of hole area is 10-20%. The limitation that the openings connecting the front and back surfaces of the plates cover an area of 10 to 20 % of the plate is found in claim 6 of the present application. Priestley, however, does not teach or suggest this limitation. Nor does Priestley teach varying the rate of hole area in order to effect a varying degree of gas liquid contact.

The term "rate of hole area" is used to provide a description of the area of the plate that is taken up by the holes through the plate. The term is found in the specification at least at page 9, lines 22 and 23 and at page 13, lines 11-15. Claim 6 includes the limitation that "openings connecting a front surface to a back surface between the adjacent rows and covering an area of 10-20 % of the contact plate." This limitation regarding the area "covered" by openings in the plate defines the "rate of hole area." The disclosure that the rate of hole area is about 10 to 20% appears at page 18, lines 11-15, for example. Based on the usage of the term and the meaning of the words in the term, the "rate of hole area" would be seen as encompassing both an area and a percentage, indicating to one skilled in the art that the measurement is the area per hundred millimeters squared taken up by the holes through the plate.

The degree of wetting by liquid drops was tested by using a device shown in Figure 6. The width of wetting spread in the transverse direction of the absorbing solution after 1

minute of the liquid drop was measured at a location 50 mm. below the point of liquid drop. Figure 8 shows the actual wetting spread w due to a liquid drop of sample 1 with a rate of hole area of 10% in the gas-liquid plate 1. Figure 7 shows the results of the test.

In Figure 6, an absorbing solution was provided from a tank of absorbing solution 50 to the upper part of the gas-liquid contact device 52 via a pump 51. In the gas liquid contact device 52, a fixing device 53 for fixing a gas-liquid contact plate 1 is provided. At the bottom part of the fixing device 53, a liquid reservoir 56 is provided where the absorbing solution was discharged out of the gas-liquid contact device 52.

Gas was introduced into the gas-liquid contact device 52 via a fan 55. The gas was brought into contact with the gas-liquid contact plate 1 at the upper part of the gas liquid contact device 52 and then discharged into the air at the uppermost part of the device 52.

Each gas-liquid contact plate 1 having openings was obtained by the operation noted at page 12, lines 7-24, of the specification, for example. This gas-liquid contact plate 1 was placed in the device as illustration Figure 6. The rate of each hole area for each gas-liquid contact plate 1 ranged from 2% to 18%.

Test conditions for the gas-liquid contact device 52 were as follows:

Temperature of absorbing solution:	about 55°C
Dropping rate of absorbing solution:	2 ml/min.
Gas flow rate:	2.5m/sec.
Gas temperature:	about 20°C.

Each plate in which the width of the wettability was evaluated had been soaked in an absorbing solution for one day after having been defatted by acetone in order to simulate the conditions of the gas-liquid contact plate in actual use.

Figure 7 is a plot showing the width of wetting spread according to each of the rates of hole area. In Figure 7, the conditions A, B and C show the combination of pitch with respect to different lengths of Y (in the longitudinal direction) and X (in the transverse direction) of the pressed shape of a plate as shown in the modified version of application Fig. 1(a) included herewith. The pressed shape of the condition A is: X = 1.2 mm, Y = 1.2 mm. The pressed shape of the condition B is: X = 1.2 mm, Y = 1.0 mm. The pressed shape of the condition C is: X = 1.0 mm, Y = 1.2 mm. As note above, this plate of the pressed shape is described at page 12, lines 7-24 in the specification. The material of the pressed plate (the contact plate) is stainless alloy. The thickness of the plate itself is about 0.2 mm.

The rate of hole area (S) is based on the following general formula:

S = (the number of openings within 100 mm^2) x (the area of one opening).

As a preliminary step to this experiment, the height of the pressed irregularities (Z) of the pressed plate was measured. This height of irregularities is shown in the modified sectional view of Fig. 1(a) of the application as is the dimension Y. Since the thickness of the plate itself is 0.2 mm, when Z was about 0.5 mm, the plate did not provide effective wettability since the opening was too small. Thus, in Figure 7 showing the wettability, the experiment was performed so that Z becomes 0.6 mm or more ($Z \geq 0.6$ mm) and X/Y have appropriate pitch. Since whether wettability is sufficient or not is determined by the relation between X, Y and Z, the plate showing good wettability can be defined by the rate of hole area which is determined by the relation between X, Y and Z.

The area of one opening can be determined by one skilled in the art. Figure 9 is an enlarged version of Figure 1 (d) in the specification. In Figure 9, the maximum spacing of the opening (h) is determined by subtracting the thickness of the plate (0.2 mm) on each side of

the maximum spacing (h) from the height of irregularities (Z), described above. This translates to the following formula for h:

$$h = Z - 0.2 \times 2.$$

In addition, the length in the longitudinal direction in the opening (a) is determined by subtracting two times the thickness of the plate (0.2 mm) from the pitch length in the longitudinal direction Y as further illustrated in Figure 9 in accordance with the following formula for a:

$$a = Y - 0.2 \times 2$$

As can also be seen in Figure 9, each opening is approximately rhomboid in shape, as shown in the illustrated hatched portion. The area of the opening is calculated based on that shape. The formula for the area of a rhombus is well-known in the art to be:

$$\tfrac{1}{2}\,(\text{diagonal 1} \times \text{diagonal 2}).$$

In the present experiment, the two diagonals of the approximate rhombus are a and h, described above, resulting in the following area formula:

$$\text{Opening area} = \tfrac{1}{2}\,(a \times h).$$

Thus, the area of one opening is:

$$\tfrac{1}{2}\,(Z - 0.4)(Y - 0.4).$$

The number of openings within 100 mm^2 of the plate is simply calculated by $100/(X \times Y)$, as would be self-evident to one skilled in the art.

Thus, based on the formula above:

$$S = (\text{the number of openings within } 100\ mm^2) \times (\text{the area of one opening})$$

$$S = \{100/(X \times Y)\} \times \{(Y - 0.4) \times (Z - 0.4)/2\}$$

$$S = 50(Y - 0.4)(Z - 0.4)/XY \quad \text{---} \quad (1)$$

In Figure 7, the rate of hole area (S) calculated by the equation (1) is plotted in the transverse axis and the wettability w described as to the showing of Figure 8 is plotted in the longitudinal axis.

As regards the condition A (X = 1.2 mm, Y = 1.2 mm), 4 points of Z (height of the irregularities) in the range of 0.6 - 0.9 mm (i.e., Z = 0.6 - 0.9 mm) were tested. The resulting rate of hole area was as follows:

Z = 0.6 mm	S = 5.56	w = 34 mm
Z = 0.7 mm	S = 8.33	w = 50 mm
Z = 0.8 mm	S = 11.1	w = 61 mm
Z = 0.9 mm	S = 13.9	w = 60 mm.

As regards the condition B (X = 1.2 mm, Y = 1.0 mm), 2 points of Z in the range of 0.5 - 0.8 mm (i.e., Z = 0.5 - 0.8 mm) were tested. The resulting rate of hole area was as follows:

Z = 0.5 mm	S = 2.50	w = 25 mm
Z = 0.8 mm	S = 10	w = 68 mm.

As regards the condition C (X = 1.0 mm, Y = 1.2 mm), 4 points of Z in the range of 0.6 - 0.95 mm (i.e., Z = 0.6 - 0.95 mm) were tested. The resulting rate of hole area was as follows:

Z = 0.6 mm	S = 6.67	w = 46 mm
Z = 0.7 mm	S = 10	w = 52 mm
Z = 0.8 mm	S = 13.3	w = 61 mm
Z = 0.95 mm	S = 18.3	w = 40 mm.

As shown in Figure 7, the width of wetting spread was large when the rate of hole area (S) was just above 10%. The width of wetting spread gradually decreased as the rate of hole area (S) was increased- when the rate of hole area approached 20%, the width of wetting was decreasing. Likewise, when the rate of hole area was about 5%, the width of wetting spread was evidently small. Therefore, in the gas-liquid contact plate having openings, significant advantageous effects are achieved when the rate of hole area is 10-20%.

It is noted that Figure 7 shows apparently good wetting spread when the rate of hole area (S) is from about 6% to 8%. However, such smaller rates of hole area (S) require smaller openings in the plate. Use of such smaller openings in manufacturing will result in the production of plates with unreliable wettability because some of the very small holes will not be sufficiently opened to be effective. Therefore, rates of hole area below 10% are avoided as not being reliably obtainable.

This experiment emphasizes the significance of the functional effects of the limitation that a rate of hole area is 10-20%. <u>Priestley</u> does not teach or suggest varying the rate of hole area in order to effect a varying degree of gas liquid contact or a specific rate of hole area for improved gas liquid contact efficiency without sacrificing reliability.

6. The declarant declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful and false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: September 13, 2004

Naoyuki Yoshizumi

Name